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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

NEW YORK, April 26th, 1899.

The 133d meeting of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS was held at 12 West 31st St., this date, and was called to order by President Kennelly, at 8.15 P. M.

THE PRESIDENT:—The Secretary will read the announcements for the evening.

THE SECRETARY:—At the meeting of the Executive Committee this afternoon, the following Associate Members were elected.

Name.	Address.	Endorsed by
CLEMENT, JOSEPH	Consulting Electrical Engineer, Messrs Eckstein & Co., and Rand Mine., Box 149, Johannesburg, S. A. R.	J. W. Kirkland. S. Dana Greene. W. L. R. Emmet.
ELLIS, R. LAURIE	Assistant to Superintendent, Augusta R'way & Electric Co., 230 Dyer Building, Augusta, Ga.	A. M. Schoen. W. E. Moore. R. W. Pope.
ELLIS, JOHN	Manager, The Lonsdale Co's., Electric Light Plant, Lonsdale, R. I.	Chas. R. Cross. W. L. Puffer. R. W. Pope.
GANZ, ALBERT F.	Assistant Professor, Physics and Applied Electricity, Stevens Institute; residence 612 River St., Hoboken, N. J.	Henry Morton. W. E. Geyer. J. E. Denton.
KENNEDY, A. P.	Electrical Engineer, Norton Bros., Maywood, Ill.	H. B. Smith. R. W. Pope. W. E. Goldsborough
LAWRENCE, W. H.	Assistant Superintendent, Second District, Edison Electric Illuminating Co., 49 West 26th Street, New York, N. Y.	J. W. Lieb, Jr., Arthur Williams. Philip Torchio.
LYFORD, OLIVER S. JR.,	Chief Engineer, Westinghouse E. & M. Co.; residence, 916 Lilac St., Pittsburg, Pa.	Chas. F. Scott. J. C. Chamberlain F. B. Badt.
MASSON, RAYMOND S.	Salesman and Engineer, Westinghouse E. & M. Co., Mills Building, San Francisco, Cal.	F. A. C. Perrine. F. F. Barbour. Clarence L. Cory.

NAMBA, M.	Professor of Electrical Engineering, University of Kioto, Kioto, Japan.	E. A. Merrill. E. E. Higgins. H. W. Blake.
PECK, JOHN S.	Electrical Designer, The Westinghouse E. & M. Co., Pittsburg, Pa	Chas. F. Scott. P. A. Lange. A. J. Wurts.
REED, WALTER WILSON	Electrical Engineer, in charge of the electrical work of new plant Citizen Electric Light and Power Co., Houston, Texas. With General Electric Co., Schenectady, N. Y.	Theo. Stebbins. W. L. Puffer. Geo. W. Davenport
SCHURIG, EDWARD F.	City Electrician, The City of Omaha, 306 City Hall, Omaha, Neb.	H. Vance Lane. W. F. White. R. W. Pope.
SKINNER, CHARLES EDWARD	Electrical Engineer, Westinghouse E. & M. Co.; residence, 424 Franklin Ave., Pittsburg, Pa.	E. E. Keller. P. A. Lange. Chas. F. Scott.
SWOPE, GERARD	Electrical Engineer, Western Electric Co., 242 So. Jefferson St., Chicago, Ill.	H. H. Wait. Chas. D. Crandall. E. P. Warner.
WELLS, WALTER FARRINGTON	Assistant General Manager, Manhattan Electric Light Co., residence, 72 East 77th St., New York, N. Y.	E. A. Leslie. E. W. Rice., Jr., J. W. Lieb, Jr.
WIDDICOMBE, ROBERT A.	Engineer, Western Electric Co., residence, 1653 Roscoe St., Chicago, Ill.	E. P. Warner. L. K Comstock. F. B. Badt.
YOUNG, WALTER DOUGLAS	Electrical Engineer, B. & O. R. R., Roland Park, Baltimore, Md.	O. T. Crosby. H. J. Ryan. Edw. L. Nichols.

Total, 17.

The following Associate Members were transferred to full membership:

Approved by Board of Examiners, March 10th, 1899.

CHUBBUCK, H. EUGENE Manager, Quincy Lighting Companies, Quincy, Ill.

BARSTOW, WILLIAM SLOCUM General Manager, Edison Electric Illuminating Co., Brooklyn, N. Y.

THE PRESIDENT:—The subject for the evening is a topical discussion upon "The Limitations of Power Sub-Division by Electric Motors in Manufacturing Establishments," and Mr. Gano S. Dunn who has had considerable experience in this direction will oblige us by opening the discussion.

A Topical Discussion at the 133d Meeting of the American Institute of Electrical Engineers, New York, April 20th, 1899, President Kennelly in the Chair.

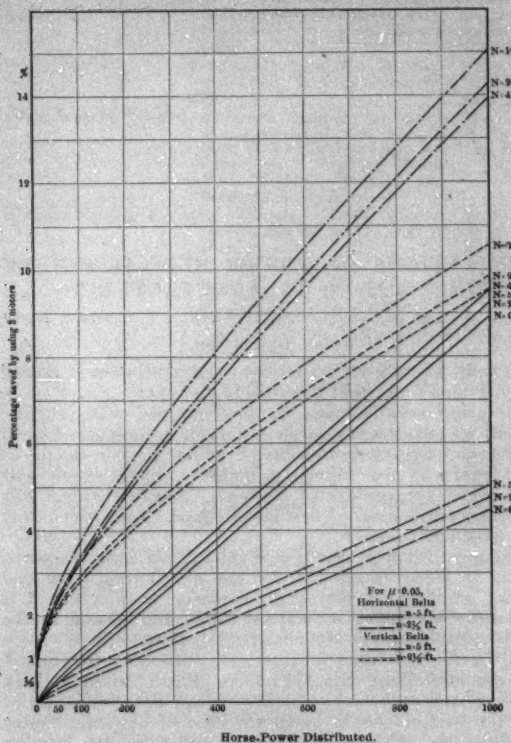
THE LIMITATIONS OF POWER SUBDIVISION BY ELECTRIC MOTORS IN MANUFACTURING ESTABLISHMENTS.

[A Topical Discussion.]

Mr. Gano S. Dunn:—Mr. President and gentlemen: Stated concretely, I should say that the topic of this evening is: "given a manufacturing establishment to be equipped with electric power, shall we put in a few large motors or a number of small ones of the same aggregate capacity?" The question should be tested in regard to the following points: First, which way would be most economical of power? Second, which way would be most economical of first cost? And third, which way would be most convenient?

The economy-of-power question divides itself into two parts, first as the economy is affected by the distribution pure and simple—the problem of taking your power from where it is generated and distributing it over the shop; and second as the economy is affected by the manner of using the tools.

To analyze the first part of this power-economy question, I have had prepared some data and curves [Fig. 1] which I think settle it, since it is very easy to make accurate determinations of just what the friction would be in the case of one large motor driving a shop, and what it would be in the case of a number of smaller ones driving subdivided shafts. My assistant, Mr. Douglass, has been kind enough to put these facts into a formula, and I have before me some curves plotted from them. I have taken as cases for comparison, one large motor and three motors of equivalent horse power. I have put the problem as whether we would have 100 feet of shafting driven by one motor, or three groups of 33⅓ feet each driven by three smaller motors. Taking a duty upon the shaft of one horse power delivered for every five feet of its length, which corresponds to light machine shop practice, and taking a coefficient of friction at five per cent., which is given in Kent's Handbook for some actual cases, taking a speed of 200 revolutions per minute, and for the first case one in which the belts driven by the shaft, pull hor-



Horse-Power Distributed.

FIG. 1.

Economy of subdivision of power. Per cent. of power saved by using three motors of equivalent power instead of one.

Power distributed equally in both directions from motors.

H = H. P. of the one motor.

N = speed of shaft, R. P. M.

n = ft. of shaft per H. P.

μ = coefficient of friction.

For horizontal belts, equally distributed on both sides of shaft,

$$\% = 0.895\,\mu\left[\frac{H}{n} + 0.080\,H^{1/6}N^{2/3}\right]$$

For vertical belts, taking total belt-pull equal to 3 × effective belt-pull, motor-belt speed 3000 ft. per minute and machine pulleys 12 in. diam.,

$$\% = 0.895\,\mu \times \left[\frac{H}{n} + H^{1/6}\left(0.0679\,N^{2/3} + 56.6\,N^{-1/6}\right)\right]$$

$$\text{Shaft diameter} = 3.7\sqrt[3]{\frac{1/6\,H}{N}}$$

25 lbs. of pulleys per H. P.

izontally in opposite directions, so that the only cause for friction is the downward pull of the weight of the shaft and its pulleys, we find on consulting the curve that the percentage saved by using three smaller motors instead of one large motor is, for a distribution of 200 horse power, two per cent.

For a distribution of 50 horse power, the saving is about one-half of one per cent. A reason why this saving is so small at these low powers is because we cannot reduce the diameter of our shaft beyond a certain point when we reduce the amount of power it has to transmit. All of these shafts for motor powers under 25 H. P. have been figured at 1¼ inches in diameter irrespective of what they have had to do. When we reduce the size of our motor and cannot correspondingly reduce the size of our shaft we cannot make the savings that a reduced shaft would permit. When we go up to as high as 800 horse power the saving amounts, with horizontal belts, to 7.4 per cent. Taking for the second case, that in which all the belt pulls are vertically downward and thereby contribute to the friction, the figures come out as follows: It is assumed that the downward pull of a belt is three times the pull necessary to transmit its power, which allows for the tension of its idle side. In this case the saving for 200 horse power at a speed of 200 R. P. M. and other constants as before, is 5 per cent, and for 800 horse power 12.1 per cent. This is all.

It is obvious that in the smaller sizes of motors which is what we have principally to do with, a saving of 1½ or 2 per cent is very easily offset and possibly reversed by a difference in efficiency. Motors of 10 horse power to 50 horse power do not, however, differ very much in efficiency, even at partial loads, at which points the efficiencies should be taken. So I think it may be safely concluded that for a case of this kind there will be no power saved when we distribute our power divided into three groups of independent shafts instead of having it one continuous shaft driven by a single motor of larger size.

The second part of the power-economy question is: If we cannot directly save anything by dividing up our shaft, can we make any savings indirectly? And the answer is that we can make very large ones. If we have a shaft of 100 feet in length, that shaft has to be kept running whether the tools operated by it are running or idle, but if it is divided into three groups, we can shut down one group or two groups that may be idle and thereby make a great saving. You are all undoubtedly familiar with the work Professor Benjamin has done in this line.

He showed that in six machine shops where heavy machine work was done, an average of 62.3 per cent of the power produced was used in driving the shafting only. In one case he found it as high as 80 per cent. This is because the shafting has to be built large enough for, and has to be kept running for, tools that are idle. People think that tools in a machine shop

are not idle very much. But it is a fact shown by careful observations that have been taken, that even in the busiest shops, the busiest tools are seldom in operation for more than 80 per cent of the time, and I think it is a safe statement to make, that the average tool in an ordinary machine shop is not actually running more than one-third of the time. The tremendous gains that electric power permits come from taking advantage of this idleness of the tools. When we have our single shaft we cannot take advantage of it. When we have our three groups of shafting we can, and we make thereby a large saving.

From the economy-of-power point of view we might sum up by saying that three shafts save little or nothing in distribution, but they save anywhere from 15 to 50 per cent by virtue of their permitting advantage to be taken of the idleness of tools.

Proceeding to the second test of our question which is that of economy of first cost, it is of course commonly known that motors as they get smaller cost more per horse power, and when we have three motors to do the work of one, it makes the total cost considerably greater.

RELATIVE COSTS OF ONE-MOTOR AND THREE-MOTOR ARRANGEMENTS FOR VARIOUS POWERS.

Length of Shaft at 5 ft. per H. P.	ONE MOTOR.		THREE MOTORS.		Increased Cost over one-motor arrangement. Per cent.
		Cost of Motor and Variable Element of Shafting.		Cost of Motor and Variable Element of Shafting.	
10 ft.	2 H. P. Motor, 1½" Shaft.	$151.	⅔ H.P. Motors 1½" Shaft.	$260.	70
50 ft.	10 H.P. Motor. 1⅞" Shaft.	$367.	3⅓ H P. Motors, 1⅞" shaft	$585.	59
4 ft. per H. P. 200 ft.	50 H P. Motor. 1⅞" Shaft.	$1230.	16⅔ H. P. Motors, 1⅞" shaft	$1580.	28
3½ ft per H.P. 350 ft.	100 H.P. Motor 2⅜" Shaft.	$2570.	33⅓ H. P Motors, 1⅞" shaft	$2505.	Decrease 2

I have had figured out, and give in the table the first costs where various quantities of power are delivered by one motor, and by three motors, and the percentages that the costs of the three motor combinations bear to the one motor standards. Taking a two horse motor and including not the whole cost of the shafting, but only that part which would vary with a change in the size of the motor, the cost of such an equipment with one motor set up would be $151. With three two-thirds horse power motors the price would be $260, an increase of 70 per cent. in first cost against the subdivided power. Taking another case in which the

original motor is 10 horse power, the cost would be $367 while the cost of three motors of 3⅓ horse power each would be $585, an increase of only 69 per cent. gaining, as you see, on the first figure. In the case of a 50 horse power motor, still larger, the cost is $1230; the cost for the three equivalent motors $1580, a difference of only 28 per cent. In the case of a 100 horse power motor, the cost is $2570, and the cost of the three equivalent motors of 33⅓ horse power is $2,505. The figures have crossed the line and show a gain of 2 per cent. in favor of subdivision. So for 100 horse power the question of whether we shall subdivide or whether we shall use it distributed from one large unit is equal as regards first cost.

These figures that I have given may not be absolute, as they have been taken, not so much to give exact data, as for the purposes of comparison, but for purposes of comparison I believe they are strictly correct.

Lastly, with regard to the test of convenience. I should say, in the first place, that half of the motor business would be controlled at once. The question of convenience is often absolute. If we wish to equip a traveling crane with motors, there is only one size of motor we can use for that crane; we have no choice whether to subdivide or not. Also if we have a saw or a punch press, or a large tool, we have no alternative but to use the size of motor that the tool demands. Therefore there is no need of discussing subdivision. The question is ruled out. I would repeat that at least one-half of the installations we have to deal with, are settled already for us by this question of convenience or practicability without any calculation or figuring on our part. It is also my experience that first cost becomes insignificant and disappears in comparison with the gains that are made by consulting convenience of operation.

I have made some figures on the value of the annual product of a number of important works in this country, and I will compare them with the value of the power used in making that product. The method I have taken to get this value, may be criticised, but I think you will agree with me it is about the only one available, since large concerns are loath to announce or to publish the volume of their business, the volume of their sales. I have assumed that material is twice as valuable as labor, and therefore that the total output is three times the value of the labor. Knowing the number of hands that are employed in these various works, and assuming that in American machine shops the average pay of an employee is $10 a week—it is found to come very close to that,—I have figured approximately the value of the product that these concerns turn out. I also have the amount of power that they use. The percentage that the value of the power figured at $40 per H. P. per year bears to the value of the product, is as follows:

RATIO OF VALUE OF POWER TO VALUE OF PRODUCT.

Union Iron Works,	$\frac{1}{4}$ of 1 per cent.
Baldwin Locomotive Works,	1.8 per cent.
William Sellers and Co.,	1 per cent.
Pond Machine Tool Company,	1.2 per cent.
Pratt and Whitney,	$\frac{1}{2}$ of 1 per cent.
Brown and Sharpe,	$\frac{1}{10}$ of 1 per cent.
Yale and Towne,	$\frac{1}{10}$ of 1 per cent.

We can see from these figures therefore, that the power that goes into the product is a very small item in itself, and that any savings we may make in that power are unimportant. If we save half of it, we do not save much more than a quarter of one per cent. of the value of the product. But here is the vital point. By introducing a system which saves our one-quarter of one per cent. in this power, we may make from 5 to 50 per cent. saving in the cost of the product that is turned out,—a saving from 20 to 200 times as great as the initial saving which bronght it about. At this rate we can afford to buy new motors every year, and throw the others away. We can afford to disregard entirely the question of the power saved, or the economy of first cost. I think this aspect of the question has not been sufficiently brought out.

I do not wish to take more than my share of the time in this discussion, but I will cite one or two instances of what I mean. In the case of a machine shop built in the modern style, where they wish to have clear head-room for a crane to carry quickly heavy pieces of machinery from one tool to another, the question of overhead belts or of belts running slantingwise from the side galleries down to the tools, which was one of the ways in which it used to be done, is ruled out at once by the fact that when we are able to put a motor on a big tool on the floor of such a shop, no one in his senses would consider driving it by belts, and obstructing the head-room. The clear head-room would save perhaps 5 per cent of the value of the labor of the shop,—in making it possible to take heavy machinery and pieces up and down it and into its various bays without stopping to clear the belts. In regard to the speed of tools we are so accustomed to having the cone pulleys which give us certain definite speeds, on our lathes and cutting tools, that we do not yet appreciate what great advantage we can get from electric motors which will give us graded speeds between those that the cone pulleys would give. In many cases where a chip is being taken, stopping to change the cone makes a defect in the work and sometimes lets the chip cool off.—I have recently seen chips being turned red hot— and necessitates a resetting of the tool. With an electric motor arrangement, very easy and smooth gradations of speed may be obtained, without jerks. This alone means a great increase in output.

The Government Printing Office in Washington is the largest printing establishment in the world, $11,000 a day being required

to run it. It used to be operated by overhead shafting, belted to the presses and other machinery below.

If we should drive this same overhead shafting by large motors we would unquestionably make a saving of power over belting it back to the engine room, but we would not make the indirect savings peculiar to the electrical system. But if we subdivide and place a motor upon each press, we at once derive enormous advantages.

This is what has actually been done in Washington, and it results in increasing the output of the Printing Office 15 per cent. without increasing the speed of the presses. The reasons are, that with direct-connected motors the driving is absolutely uniform, which makes possible the preservation of what is called the register of the presses, which is the accuracy with which they will fold a sheet into eight or sixteen pages after it has been printed. With belt driving, on account of the different degrees of slippage at the moment of impression, resulting from atmospheric conditions, and inequalities of speed resulting from the wabbling of the belt to the crown of the pulley and off again, considerable irregularity is introduced, which makes preservation of register more difficult.

Also in "making ready," that is, preparing the press to print, by making a great many trial impressions and adjustments, the remarkable facility of control of electric motors which may be started, stopped, reversed, moved very slowly or very rapidly, permits this tedious operation which requires a number of hours, to be done much more quickly than where the control has to be effected by slipping a belt on and off a loose pulley. The saving of waste of paper and labor resulting from the absence of overhead gear that churns up the dust, and drops oil upon the presses and their work, also contributes to this increase in output.

All of these advantages do not involve the question of power, but are results of the greater convenience in direct-connected motors over belted ones. It can be readily seen that in the Government Printing Office the question of the limit of power subdivision would never be raised. The 15 per cent. increased output would pay many times over for whatever difference there would be in the first cost.

I would make the following conclusions:

First:—Where we have to decide whether we shall install one large motor or a number of smaller ones, I would give preference to the smaller motors down to a limit of 5 H. P. for light machine shop duty, and 10 H. P. for heavy machine shop duty. This for cases in which the problem is one of distribution only.

Second:—Where the introduction of motors would have any effect upon the product, I would dismiss entirely the question of power and decide solely with regard to the convenience of operation afforded, and would not hesitate to put in the very smallest motors, mounted upon any kind of machinery, notwithstanding

their greater cost and lower efficiency, if they even to but a slight degree increased the product of the labor of the shop. Gains in this direction cause other gains to sink into insignificance.

Mr. R. T. E. Lozier:—The subject for discussion to-night is a very broad one. It covers a very large field. The question comes up whether the use of individual motors in all cases is desirable. I do not think that that general proposition holds true. The conditions governing the operation of machines enter very largely into the problem. The equation is one that is rather complicated and made up of a number of factors. I do not think that the general proposition can be held that individual motors applied to all machines, whatever their nature, is desirable.

If we separate the cases, there are a number to be taken into consideration. The general machine shop, one in which a number of tools of different types and sizes are used, such as Mr. Dunn has described this evening and given some very valuable data upon, is perhaps one of the most common ones. The printing press room is another one, and the cotton, silk and woolen mills, in which different forms of looms are used, all come under consideration. I think that the last instance is one in which we have got to wait for the future development of electric motive power. As concerns the first two, the machine shop is something that we are developing gradually. The printing press is beyond the state of development. I think that it has been clearly demonstrated that the individual motor throughout the printing establishment is the desirable method of applying power, for this reason:—In the printing press establishment, the question of cleanliness is paramount. The question of speed control is of very great value. All of these affect the product. As Mr. Dunn says, in the Government Printing Office at Washington, perhaps one of the finest examples of individual motor application, they have increased their output by 15 per cent. I verified that general figure myself by experience, and it is undoubtedly true that the man who buys individual motors in a case of this kind, pays for his equipment before the end of the year. As concerns the machine shop, which is a very interesting problem, one that we are all busy with, the general lay-out of the shop I believe governs the case. The shop is probably divided into two sections,—the main part of the shop, the nave, in which the traveling cranes are most commonly used, and the coves.

I think that we are all prepared to agree to the general proposition that the large tools that are set out in the middle of the shop in the path of the traveling crane should have their individual motors so located that the crane will be accessible to deliver and handle the material. We have lately made a large equipment in which we have done more than introduce the general form of large tools in the middle of the shop; that is to say,—we have brought the lathes and small drill presses out into

the middle of the shop, where the traveling crane can also deliver to those tools (see Fig. 2). We have gone further than that and have put individual motors on every tool throughout the shop (see Fig. 3). Every tool in the shop which I have in mind has an individual motor on it. The general effect is remarkable. It is almost impossible to comprehend the appearance of a shop of that nature to those of us who are accustomed to an ordinary belted plant. The shop is very light and very clean. The general ventilation is excellent, the absence of dirt, etc. is very evident. In addition to that, the speed control, which Mr. Dunn referred to, is a very important feature. The men become accustomed to handling their

FIG. 2.

tools in a very much better way. The product is not only produced at a higher rate, but the product itself is very much better. That applies particularly, if I may deviate for a minute, to the printing press industry where the run of the paper has a great deal to do with it—the nature of the work, whether it is half-tone work or ordinary type work—the condition of the ink—these all enter into the product, and they vary throughout the day sometimes, so that if the operator has within his own control the means of changing the speed very readily, he can adapt the speed of his presses directly to the different constants or to the different factors that go to make up

the product. That also applies to machine-shop work, and that leads up to a very important consideration in this whole question of power transmission,—that is the method of controlling the speed of the machines. In ordinary machine-shop practice the range of speed of the machines is very great, and it is a very difficult one to cover, because as the speed runs down, the torque sometimes increases. A large lathe running at a slow rate and having a heavy piece of work on, the torque of the motor is increased, and the cutting of the tool is also at a greater duty, and you cannot use the common methods of straight armature resistance and field commutation, so that we have got to get some good system of speed regulation; that is essential. It means that in laying out equipments of that kind, you have got to have a comprehensive scheme of distribution and regulation. It has got to apply to the entire equipment. I do not believe that you can use the methods which have been customary, although not exclusively employed in the past.

FIG. 3.

With the system of speed variation applied to individual motors, you get the improved product at a higher rate. You get excellent light and ventilation. The tools are kept in better shape by virtue of the fact that the general state and condition of the shop is improved. The men get accustomed to doing better work. The *esprit de corps* seems to be raised. The dropping of dirt and oil is not so great, and you can paint your tools, for example with this alumina pegamoid (such as the letter boxes are painted with). The general effect of the shop is very much improved throughout. I should like to read you an answer to a letter that I have, referring to the practical operation of this shop using individual motors, that I have in mind. I put certain questions to the superintendent, and I will read these points just as they occur. I asked him this general question, "Whether "all tools in a conglomerate tool shop should have individual "motors?" The answer is this: "The results and advantages "of a shop operated by individual motors are, that when no work

"is being done, no power is being consumed; more perfect speed "control can be obtained, and the operator always has at his "command the full limit of his machine." *** I think that this is a very important point. I think that if Mr. Dunn's analysis of the matter is followed out, it will be found that the cost of the equipment becomes insignificant because of the increase that it is possible to obtain in the product of the factory due to the improved methods of speed control. It might be looked at in another way perhaps; the percentage of the cost of the power to the cost of the product is very small; but the saving in power will probably represent a considerable interest on the investment for the motor equipment.

*** "More perfect speed control can be obtained and the "operator always has at his command the full limit of his ma- "chine. Simply by moving a lever he stops, starts or reverses "and also gets a wide range of speeds without any other move- "ment on his part except to handle the lever which can be "arranged to be immediately under the operator's hands." ***

It is also possible to get a very much greater number of speed increments. The average cone pulleys I think have as a rule about six variations, while with some of the improved methods of motor control these can be increased to eight or ten.

*** "This I consider the principal advantage of the system. "Operators on belt-driven machines will allow their machines to "operate at speeds that are not suitable to the work in hand, "rather than go to the trouble of shifting the belt; while on "the other hand, by simply moving the lever, they can alter the "speed and can handily do this. Another advantage is that the "head-room over the machine is left unhampered. Machines "may be set where they may be served by traveling cranes to "the best advantage. Another incidental advantage is that ma- "chines can be moved from place to place very readily, as all "that is necessary is to change a few connections."

I have seen that point exemplified in a number of cases where in machine shops the machines have to follow the exact lines of shafting and belting. Sometimes they place their machines at inconvenient points, where, if they have the individual motors, the shop can be arranged at will. It very often happens that the growth of the business is such that machines that were conveniently located at one time become inconveniently located, and the space which they occupy, and particularly in the case of large tools, is wanted to be occupied by smaller tools. Then these larger tools can be readily moved to points of greater advantage. Often times these points are in nooks and corners of the shop, where while it is not impossible to reach them by belting, still it becomes awkward to do so.

My correspondent continues:—

"Another advantage is the cleanliness of the shop, and this is "of no minor importance. It is well known that belts cause

"circulation of air in the shop which deposits dust particles on "walls and ceilings."

I asked him what the item of repairs and maintenance was in a shop using individual motors, and he says "That it is no more "in a shop equipped with motors on every tool, than with a belt-"driven outfit, provided that the motors are in the first place "adapted to the work." The adapting of the motors to the work is something that is coming along, I think, as the business progresses, because when the power has once been determined it is a constant, and that size of motor can always be employed for performing that work on that particular tool. That leads up to the question of how much difficulty there was in obtaining tools built for individual motors. This shop that I have in mind has grown very rapidly, and they have had to buy tools on short notice, and the question came up in my mind, or at least I thought it best to ask the question, if the inconvenience in waiting for these special tools was sufficient to offset the advantages that were obtained from the use of these individual motors. The answer is this: "We have some difficulty in obtaining tools built "for individual motors, but this will gradually eliminate itself as "the demand increases." *** That is to say, the tool builders, as the printing press people are doing, will begin to adapt the head stocks and the driving gears of their machines to these motors; so that a man can order either a belt-driven tool or a motor-driven tool, as the case may be, and get it just as quickly. It is going to be inconvenient in changing over from the old school to the new, but in the case in point the difficulty has not been insurmountable. They have been able to overcome it.

*** "In fact most builders are willing to make the necessary "changes at the present time, at least all of the enterprising "ones." As stated before, the speed control is far superior to the belt system not only in its range, but in the ease of adjustment. I then asked the question: "Would you return to the "belted system under any circumstances?" The answer is, "I "would not return to the belted system under any circumstances. "This I consider, however, no argument, as it is only the expres-"sion of a prejudiced person."

The question then came up of whether the geared motor or the slow-speed direct-connected motor appeared to have the greatest advantages, and then considerable follows in which the question of applying the direct-connected motor or the geared motor to various classes of work, and it seems that it depends a great deal on the nature of the work. Taking the question of lathes where the torque increases inversely as the speed; in the larger lathes the direct-connected motor is more adapted, but when it gets down in the smaller sizes of lathes,—20-inch lathes and smaller—the torque is so great, the size of the motor is so large, that it cannot be conveniently placed in the head stock, and consequently a geared motor of higher speed is used, but the

general idea seems to be that each individual tool has got to be considered by itself, and its different features worked out, and there does not seem to be any clear line of demarcation; each tool is a separate proposition, and the form of motor to be applied is governed entirely by the conditions under which that tool operates. In answer he says: "So much for the motors themselves as connected with machine shop tools, but the subject of the greatest importance in connection with this matter is the supply of electric current." Then he goes on to describe the different schemes of speed control that were tried and comes back to the original proposition that in case of a large equipment composed entirely of independent motors where speed control is desirable, it has got to be taken as a general proposition; it hardly seems feasible to apply the old established methods that we have been following in the past.

This speed control must be obtained either in the construction of the machine or in the method of giving it potentials. The system must be so arranged that this speed control can be obtained in a manner to give the motors a constant torque, irrespective of the speed and with the highest efficiency.

It is also necessary to have some comprehensive system applying to all of the motors of the installation or to such as may be necessary, which will accomplish these speed conditions. It perhaps requires some courage to do this, but the results well warrant the effort, as has been successfully demonstrated in the example that I have cited this evening.

MR. H. WARD LEONARD:—I should like to emphasize a little the fact that rheostatic control is adapted to only a very small line of speed control of motors. Where you have work in which the torque increases in some definite way as the speed increases, as for example, a centrifugal pump or a ventilating fan, a rheostat gives a very nice method of securing the control that is desired, as each particular speed represents a definite torque and the control can be quite perfect, and the speed can be maintained at any speed that is desired. When, however, the torque is independent of the speed, as is usually the case, or where, as in some few instances, the torque varies inversely as some function of the speed, then it becomes of the first importance to see that in a practically constant field you supply the armature with a net voltage which will be available in proportion to the speed, and there are quite a number of ways of securing this result, and two or three methods I have already described before the INSTITUTE and there are two or three modifications which I will make a few comments about.

Referring to Fig. 4., s is to represent the generator of constant E.M.F. which for convenience in handling the figures we will call 100 volts, and R is a rotary transformer consisting of three armatures which will revolve continuously across the outside voltage and having the armatures so wound as to create upon a 4-wire

system, constant potentials, such that between the outside wire and the first conductor there will be 23 volts; between the two middle conductors, 33 volts; between the third and fourth, 44 volts; thus giving us available six different constant electromotive forces as follows: 23 volts, 33 volts, 44 volts, 56 volts, 77 volts and 100 volts. This system will be available for operating

SPEED.	DIRECT ROTATION.		REVERSE ROTATION.	
	Lever A on Contact.	Lever B on Contact.	Lever A on Contact.	Lever B on Contact.
0	1	1	1	1
23	2	1	1	2
33	3	2	2	3
44	4	3	3	4
56	3	1	1	3
77	4	2	2	4
100	5	1	1	5

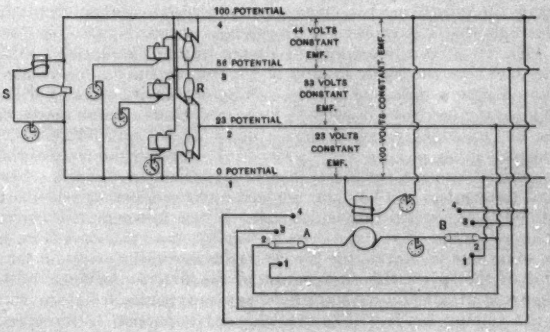


FIG. 4.

the lights in a factory and supplying all purposes which require only a constant electromotive force, and will also give throughout the shop at command these six different constant electromotive forces.

The field of the motor would preferably be wound so as to be connected across the outside wires and would have a field rheostat

for such partial regulation as might be desired in that way, and each one of the four constant potentials represented by the four different wires would be led to different contacts of a switch with a contact lever which would enable you to connect one brush of the motor to either one of the four wires, and similarly to connect the opposite brush to either one of the four wires. Thus you can get upon this armature, while in a constant field, and a field which is independent of the armature current and independent of the opening of the armature circuit, any one of the six constant electromotive forces, and you can get them graded in order, and you can get them reversed. Of course I have shown this in a very crude, simple form; but a controller devised to give such gradations of voltage upon the armature, with intermediate gradations, if desired, of ohmic resistance, will enable you to operate any motors through a manufacturing establishment in either direction at these six different automatic speeds; and generally speaking, if you can get six graded speeds such as this, and can get field regulations to carry you from one to the other, or if desired, rheostatic regulations to secure intermediate speeds, you can fill almost all requirements that are met with in manufacturing plants. The size of this rotary transformer would in all probability, in a large, comprehensive establishment, be, in kilowatt capacity, about 20 to 25 per cent of the kilowatt capacity of the main generator; for you will understand that all motors which are being operated at full speed do not require any of the current that is going through the rotary transformer, and those that are operating at the highest speed affect only a portion of the rotary, and as a consequence, there will be times when one of the sections of the rotary transformer may be operating as a motor, another section as a generator, and so forth. There may be any one of several different conversions going on there, depending upon what conductors the motors are connected across.

Another form of control which sometimes has its uses, is this: Suppose we have the familiar 3-wire system, and that we have 100 volts on each side. Suppose we connect the armature of the motor to be controlled, between the middle wire and one outside wire. Let us call the potentials of the 3-wires of the 3-wire system 0, 100, and 200, and suppose one motor armature is connected between 0 and 100 potentials, so that it is subjected ordinarily to 100 volts constant E.M.F. Now let us place in series with our motor armature across the constant E.M.F. of 100 volts, another armature which is driven constantly at full speed in one direction of rotation and revolving in a separately excited field, which is variable and reversible. Suppose this regulating armature is wound for 100 volts when its field has its full strength. Evidently we can cause the 100 volts of this regulating armature to either assist or oppose the E.M.F. of 100 volts across which the motor armature is connected. Thus we can se-

cure upon the terminals of the motor any E.M.F. from 0 to 200 in a constant field. The amperes through the regulating armature and the motor armature will be the same, but the maximum E.M.F. of the regulating armature will be 100, and the maximum E.M.F. on the motor armature will be 200 volts. That is, the watt capacity of the regulating armature will be only half of that of the armature of the motor to be regulated. A convenient way of operating the regulating armature at constant speed will be by driving it by means of a shunt-wound motor connected across the constant E.M.F. The chief novelty of this scheme consists of starting from an intermediate potential such as that upon the central wire of a 3-wire system and connecting to such intermediate potential, one terminal of a generator of variable and reversible E.M.F. and thus developing at the other terminal of the generator, a new potential controllable over a wide range. This new variable potential can readily be carried beyond the potential of the outside wire of the 3-wire system so that the direction of the current would reverse in a motor armature connected between this variable potential and the potential of the outside wire of the 3-wire system.

Another modification which is sometimes convenient, and which I first put into commercial practice in 1891, at the works of the Eddy company, is to control a machine where, as when some conditions are met with, it is important to have perfect control at very low speeds, but it becomes unimportant to have very good control except at such reduced speed. Under such conditions a large motor can be controlled with a small motor-generator, the motor end of which would be connected across the full voltage; the generator end of which would be of few volts and many amperes and so arranged as to supply, in starting and at low speeds, the armature which is going to be operated and controlled, and after you have reached the limit of the speed represented by the low voltage at the generator end of your small motor generator, you step off from that point either to a rheostatic control or something like perhaps the series parallel control, though the rheostatic control is the one that is simplest and cheapest. In the instance at the Eddy works the motor was a 500-volt motor and a motor generator had its primary end supplied with 500 volts, and the secondary end produced as a maximum 100 volts. At that time I was trying to devise schemes for operating large presses and things of that nature in which the control of the press at very reduced speed was a matter of the first importance, but where it becomes comparatively unimportant as to having perfect control beyond the reduced speed; and in the effort to try to secure the reduction in the size of the necessary equipment I put this into use and it worked all right, but the added complication of the switch device which was required, made me believe, and I still believe, that for most instances it is best, on account of simplicity, to spend a little more

money in the beginning and get the most simple equipment possible. Such an arrangement as that described is perfectly feasible, and it reduces the size of the necessary motor generator equipment materially. I wish to point out that quite frequently it may be advantageous to replace the rotary transformer equipment in Fig. 4 with a storage battery, which nowadays has become far more favorably thought of than heretofore, and very frequently may be a feature of an equipment of a manufacturing establishment. Of course when you have a storage battery you have plenty of available points for connection, and can thus create any desired intermediate potentials that you may wish to have.

MR. F. M. PEDERSEN:—I would like to ask Mr. Lozier to explain an apparent inconsistency. If I recollect his remarks correctly he said at their beginning that he did not favor putting independent motors on tools; that is, carrying the system to its extreme by putting a motor on every tool, but that he inclined toward group driving; and yet he spent most of his time in describing a shop in which there is a motor on every tool without exception. I would like to know whether I misunderstood his first remarks.

MR. LOZIER:—My first remarks referred to the general proposition of individual motors on all machines, not necessarily tools, and I went on to specify the machinery, referring to the machine shop, and the printing press shop in which the individual motor seemed to be advisable, and then going on to the weaving machinery, in which the unit of power in each case is very small, and in which the group system seemed to be advisable. One reason for the group system in the case of these weaving machines is the question of the constancy of the speed and the ease with which additional looms can be added. I believe that in a large industry in which one class of machinery, either a loom or something of that nature is used, that the tendency now is to establish a certain ratio between the cost of the motive power and the machine. I think that to-day, although it may not apply later on as electricity develops, and is better known that it can be stated that where the cost of the motor exceeds the cost of the machine that it is to drive, where that class of machines preponderates in an industrial establishment, that it is not commercially practicable to use the individual motor. Where, however, the number of such machines or tools is smaller than the general run of tools in the factory, or whatever industry it may be, then of course that rule does not govern. I think that answers your point.

MR. GEORGE HILL:—I hoped to hear rather more of the discussion before participating in it, because the experience which I have had has been mainly in the line of printing press and bindery work, and while the results are probably applicable generally, as instanced by the results given by Mr. Lozier, yet a

general proposition can not safely be taken from one branch of industry. The conclusion which I have reached after installing the American Book Company plant and watching its operation for nearly three years, has been that in general there is no theoretical limit to the economical subdivision to which we can carry the application of the motor to the machine. There are practical cases, however, such as have already been instanced, in which there is such a limit. In the American Book Company plant we had a great many Smyth book-sewers which required about one-tenth of a horse power to operate. They were all run by operatives on piece work, some of whom were much pleased with the individual motors which were put on, and others were much displeased, and those that did the best work were the ones that were the least pleased, because the little motors which gave a speed of some 55 signatures a minute at the start, dropped after warming up, to about 40, 44 and 45, decreasing the output. We then changed the twelve machines, and drove them by means of a half-horse power motor with a three-quarter inch shaft placed on the floor, giving a speed of 60 signatures per minute, and this was satisfactory. If the motor had been sufficiently perfect to have maintained its speed throughout the entire day's run, the application of the individual motor to the individual machine would have been perfectly satisfactory. In this plant we have a number of $\frac{1}{4}$ and $\frac{1}{2}$ H.P. motors giving perfect satisfaction.

Economically, the American Book Company's plants originally manufactured 14,000 books a day at a fuel cost of about $45, obtaining simply the manufacture of the books. In their new plant the fuel cost is about $8.50 a day; they are manufacturing 22,000 books a day; operating their New York offices, and the general offices of the corporation; lighting the entire building; operating all of the elevators required for the manufactory, (9 stories); and in addition operating two high-speed high-capacity hydraulic elevators, required for the service of the three upper stories by the owners of the building in which they are the tenants, and for which they operate the plant. Our preliminary estimates showed but very little difference between the cost of installing the usual Corliss engine, vertical shaft, and various horizontal shafts on each floor and the electric installation.

Two great difficulties to be met by the designing engineer in plants of this kind I think exist still, I know I found them serious; one was that absolutely no information was accessible as to the amount of power actually required to operate the various machines when in good adjustment. I had hoped to be able this evening to place on record some of my observations there, but a sudden press of business made it impossible for me to get at my data. As an illustration, one of the machines weighing about three tons, a very heavy machine, running at a low rate of speed, was stated by its maker

who had done nothing but manufacture this type of machine all his life, to require about five horse power to operate it. I concluded from my observation of the machine operating with a four-inch belt, that he was very much in error, and I put a half-horse-power motor on and the maximum of current required for the operation of that machine with the largest book that they could put in it was three-eighths of a horse-power. The second difficulty is to know when a machine is properly adjusted. In one of the large Cottrell sheet perfecting presses, the man that erected it claimed that it was in perfect adjustment. It was taking 7½ horse power. I concluded that he was in error, and after considerable wrangling showed him how to use the ammeter and tachometer and finally having to show him where in his press the friction losses were, we reduced the power to four horse power. We put in five Hoe presses. Four of those presses operated very nicely with three horse power, one required nearly five. The Hoe company said "Of course that is in your motor. There is no question about it. The Hoe company does the very best possible work. All of their work is absolutely the same, and if one press requires any more power to operate than the other, it is unquestionably in your motor." Well, we argued it a little bit and finally we took the cylinder out, scraped one of the end blocks a little and put it back again, and we lost that additional horse-power. It came right down to where the others were.

In another plant that I have in mind, the press had recently come from the maker, and was said to be in perfect adjustment, and as an illustration of it the press tender showed me how it worked. It was a belt-driven press and he threw the belt on just for a moment, so as to throw the bed direct into the air cushion and then threw off the belt. The air cushion was quite strong enough to throw the bed back again and into the entrance of the opposite cushion. The power to operate that press was at least two and a-half times as great as it ought to have been, and showed violent fluctuations that were not necessary. The information therefore that an engineer needs in order to intelligently consider the problem at the start, is such that a few engineers have, and which is not generally published, so that he must rely on his own good judgment and expect to make some mistakes in the attachment of the motor to the machine to be driven.

Another interesting experience, perhaps, as illustrating the enormous waste of power in belting, which I had, was primarily occasioned by the endeavor of a certain company to demonstrate the superior efficiency of a very low-speed motor directly connected to the shaft of a press. They had this motor connected up, and in order to compare it they sent down one of their high-speed motors which had a four-inch pinion and was belted on about five feet centers to a 30-inch wheel on an extension of the shaft. They operated first the high-speed motor and then the

low-speed motor with the same form. The result was that the low-speed motor took about one and one-half horse power and the high-speed motor took about two horse power. I suggested that that was not a very fair test, so we raked out of the scrap-heap an old broken gear-wheel that was cobbled up with a piece of scrap-iron on the back and a pinion, and we put exactly the same motor on, gearing it, after which the geared motor took seven-eighths of a horse power as against one and one-half horse power for the slow-speed motor. The American Book Company's plant has a number of both kinds in operation, and the chief engineer informs me that he would very much rather have the geared motor running at relatively high speed than the low speed motor; that it operates more satisfactorily and gives him less trouble and takes a great deal less current. In regard to varying the speeds I think we accept conditions that would be laughed at if offered to the old mill engineer to meet with shafting and belts, and are the outcome of the disinclination of the shop owner to properly equip his shop with machines for the work. With the usual methods we can give as wide a range of speed as is really necessary, cut the coal bills in two at least, and maintain the speed at a uniform rate and this is not possible with belting. It is my judgment that every machine requiring one-quarter horse power or more, should have its own motor, either series or shunt wound, according to its work. If smaller motors are ever built that will maintain a uniform speed for a 10-hour run, install them where needed.

MR. H. B. COHO:—I recently had a talk with a very prominent manufacturer which led me to believe that this matter of subdivision of power is largely a matter of the amount of money a man intends to invest. The situation is this: They were operating a line of sewing machines with one motor running at about 500 revolutions per minute, directly connected to the line shaft. This motor operated 100 sewing machines and had cost the purchaser about $300 and about $100 for shafting. He was inclined to think that individual motors on each machine was what he wanted, and I made a test for him, putting individual motors on several sewing machines. I found that the 100 sewing machines operating with individual motors would take about 20 amperes more than the motor running the 100 sewing machines from the shaft. These figures are, of course, based on the entire 100 motors being in operation. After I described to him the extra current required he was still interested and desired to go further into the matter. He asked the cost of the 100 motors and I said about $1,800. I thought of course this would kill him, or cause a fainting spell, but it didn't. He calmly remarked, "that represents only $80 per year." He said further, "the whole matter to us is this: What we wish is the least liability to break-down and the greatest convenience for our operators. In depending on one machine we might have a break-down which would be

serious, while with 100 machines we would hardly be liable to have any machine out of service any great length of time." I told him we would be very glad to make the 100 motors. This is the first case of this nature that I have ever had. This leads me to think that purchasers are beginning to look at these matters largely as one of investment, and that, as Mr. Dunn said, the percentage of operating cost is so small in relation to the output, that it is largely from a consideration of the convenience and freedom from accident that will govern the extent to which individual motors will be used.

Mr. Oberlin Smith:—Referring to Mr. Dunn's remarks about the percentage of the cost of power to the product of a machine shop, my experience in the Ferracute Machine Company is that it is about one and one-half per cent. This agrees pretty nearly with some of the other people's figures. In general, in regard to the matter under discussion, some of you may know that I have been talking individual motors as an eventuality for several years, even at a time when anybody was thought somewhat of a crank who did advocate them. Some eight or ten years ago it was very cranky indeed. I still think, and always have, that absolutely individual motors on every machine is the ideal method; I do not say as yet the practical method. Five years ago it was a very impracticable method and we thought then that it was proper to adopt them only occasionally. Now it seems to be becoming more and more the proper thing to put in smaller motors and more of them.

The slow movement of this reform is due partly to the conservatism of the public, which of course will pass away in time. Motors are being not only improved and cheapened but they are being adapted to the particular work that they have to do. In my own practice at present I usually put motors on individual machines where they require about two horse power or upwards; but where they run below that, I try to use the group system. Of course this will depend a good deal on the *kind* of machines. In the ordinary machine-shop, where there are a great many small drill-presses and lathes, taking a fraction of a horse power each, the best present method would seem to me to be, to use as much group driving as can be arranged with those small machines; then on the larger one's using say above two horse power, apply individual driving wherever practicable, or apparently best. Of course there are exceptions to all rules.

In regard to the advantages mentioned by Mr. Lozier, I fully agree with the quotations he read. Other matters that I think were not mentioned were, first, the much greater light that is gotten in the shop; second, cleanliness; third, more room overhead; fourth, and quite important, extra safety. We all know the danger in machine shops of big shafts winding people up; and of belts flying off pulleys; and sometimes of a hanger falling down with shafting, pulleys and other things on men's heads.

We get rid of all this with the electric drive, and have nothing but wires under the floor.

Another geographical advantage, so to speak, besides those that other speakers have referred to, is the ability to put machines away from the natural positions of lines of shafting and not to limit them in direction. With individual motors we can turn the machine around any way. We all know how awkward it is if we have a long narrow shop and a row of lathes standing (as they must) parallel with the line of shafting, to put planers there also,—as planers are usually arranged for belting. Such awkwardness frequently comes in, cutting up passage ways etc. into a sort of maze. With electricity we can stand machines around anywhere, cat-a-corners or otherwise, and move them about freely, without keeping to parallel lines or anything of that kind.

What we badly want is a further reduction in price on small motors. This is bound to come; it is coming rapidly, and will come very much more rapidly than it has so far, when we make motors not by the 50 and 100, but by the 1000 and 10,000, as we do sewing machines and such things, with a great many "special" tools. Then of course the price will be much lower; and the demand and supply have got to react on each other as we go along to bring such a state of things,—but it is coming!

It seems to me that another thing which is holding back the use of motors a good deal, in machine shops especially, is imperfect control. The methods mentioned by Mr. Leonard are very interesting, and it would seem that something of that kind, the running of a number of wires from any proper source, carrying various voltages, as he speaks of, running such group of wires to every machine, and then picking up special voltages as we want them by proper controllers, might very likely be the coming method. This, however, can be left to the electricians to work out. I can tell them, from my mechanical standpoint, that good control is the thing we want worst of all, not only the control of a few speeds at a somewhat varying rate, but of many speeds at a great variation.

Consider the ordinary machine shop, which gives very severe conditions for changes of speed, although not so much for changes of load; take a 20-inch lathe that we want to run at say, about 25 feet a minute cutting speed. If we are turning half-inch work, we want 200 revolutions a minute; if we are doing 20-inch work we want only 5 revolutions. This is a tremendous variation, much greater than any of the ordinary controllers would give, and much greater than any motor can be expected to work efficiently at. Perhaps the remedies will come in this way, that we will specialize our lathes and such machines more; we wont try to run one lathe from 20 inches down to half an inch, but will have one that runs from 20″ to 10″, another from 10″ to 5″ and another from 5″ to $2\frac{1}{2}$″, etc. The electrical men

will not then have to make such tremendous variations of speed. In drill-presses we have a more moderate variation, while in milling machines we have a little, and in planers scarcely any. All these are problems to be worked out; to adapt the motors as far as possible to the present lathes, but also to try and make the lathe makers and users adapt their machines to the electrical conditions, which seem to be somewhat limited in spite of everything.

My experience in this work has been more especially with punching and drawing presses than on other work, and I lately have had a number of motors sent to me to put on presses. Among these were eight large presses using, on an average, from three up to six horse power. We equipped all of these with individual motors, and then we had several smaller presses taking from one-quarter to three-quarter horse power each, which were arranged in groups of four or five with a small motor to drive the group, putting the shaft on the floor so as to keep the overhead space clear.

Since then I have built and equipped a lot of presses for the Navy Yard at Washington for drawing brass shells for cartridge cases for rapid-fire guns of various sizes, from one-pounder up to six-pounder and three-inch. The complete plant, as far as the presses went, was all driven with individual motors, the largest of them 15 horse power and the smallest 5 horse power. Then there were a few trimming lathes which were driven with very small motors.

The conditions in presses are, of course, vastly different from what they are in machine shop work. In the latter the great desideratum is an immense difference in speed and not very much variation in load. In presses, except in a few instances, we need no variation of speed.

There are sometimes little automatic armature notching presses that run from 50 to 200 revolutions per minute and want four to five different speeds, but these are only exceptional cases almost all of the ordinary punching, drawing, cutting, and shearing presses running at a constant speed. We have only therefore to contend with the need of a great variation of load; and before having experience with them it might be thought this would be somewhat difficult, and that the electrical men would have to be called on to do a good deal of puzzling to get things right. They seem, however, to have done all this naturally, and we can buy motors in the open market that give the tremendous variation required without any trouble at all. It is quite interesting to put a three horse power motor on a press and see the power shoot up to 12 and 15. I have seen it go up even as high as 18 or 20 horse power, at the peak of the curve, for an instant, without hurting the motor, and on a five horse power motor run up to 30 without any trouble at all. The diagram of power is a little peculiar. With a five H. P. motor driving a good sized

punch press about half a horse power is used when the fly-wheel is running loose. The moment the clutch is thrown in there is a very sudden rise until the inertia of the shaft and attached parts is overcome, when the curve falls rapidly to perhaps one horse power or so. If it was not for the heavy ram of the press the line would run along at this, but as the ram goes down, there is, by reason of gravity, a still further decrease of power. When the crank passes the lower center and begins to raise the ram, the load increases but not quite up to the little peak caused by the clutch being thrown in. As the ram gets up towards the top the power dies away, and as the clutch is thrown out it drops down to the original level. All this is when the press is running, doing no work. Ordinarily, when we are doing work, as for instance, punching thick iron, the punch striking its surface when the ram is perhaps half way down, the first quarter of the diagram will be the same as before, but the peak will be very abrupt, rising to a great many horse power. If the punching pressure was uniform as it went through the metal a flat top to the peak would run along for a while, but of course as the punch gets into the metal it has less and less to cut, and the line falls till the wad of metal is loosened, when a sudden drop occurs, a rise of small hight following it as the stripping, or getting the punch out of work takes place. The conditions are different in the drawing press, where the work is struck rather soon after the ram begins to descend; and in drawing a deep shell like a cartridge, or a deep cup, or a seamless can, the power is nearly continuous during the whole stroke, so that the high peak continues straight along in a tableau for a good while and then comes down as the punch is being pulled from the work. For very severe service we have found compound wound motors the best, although we have used the ordinary shunt motor with fairly good success.

Mr. Townsend Wolcott:—I would like to ask Mr. Smith one question. The diagram represents the power actually taken to do the punching, drawing and so on, but it is not the load thrown on the motor, is it?

Mr. Smith:—Yes, it is thrown on the motor.

Mr. Wolcott:—Where does the fly-wheel come in?

Mr. Smith:—Sometimes we run presses with but a very small fly-wheel, which stores up but little energy. Of course with a heavy fly-wheel there is more such storage, and the maximum load on the motor is lessened. For this reason we aim to have as heavy fly-wheels as we dare to, but we have to keep them light enough not to break down the presses if crow-bars and such things get accidentally thrown between the dies.

Mr. Wolcott:—The presses that I have been familiar with, running them with a belt, have a fly-wheel heavy enough to take off a very large portion of that peak; that is, to flatten out the curve a great deal.

MR. SMITH:—Yes, that is true. The fly-wheels we generally use, do flatten out the peak and round off the little humps—so to speak. Of course the peak is much sharper and higher without a fly-wheel. The characteristic form of the curve is the same, however. This is what I attempted to show in my blackboard illustration—without trying to fix any particular amplitude, due to the presence of more or less fly-wheel storage.

MR. WOLCOTT:—Another point in regard to one of Mr. Hill's remarks. I find the same thing myself, that manufacturers of machinery, all sorts of machinery, do not know anything about how much power it takes to run it, and sometimes if they do know it, don't want to tell, because they think if they state it takes a certain amount of power it will interfere with the sale; because they think people would be scared by the amount of power it takes. The machinery which Mr. Hill mentioned mostly took less power, some of it took a good deal less than the makers thought. On the other hand I found machinery to take more, in two different cases where I fitted up machinery for mechanical engineers. One was a very well known mechanical engineer. He was very certain he understood the power himself, how much power the machinery took, and he always underestimated it; so that although I put in a great deal more power than he said he wanted, there was only just enough when we got through.

MR. JAMES HAMBLET:—The discussion so far has been almost entirely in reference to the application of individual motors to the machine shop. A little hint was given by one of the speakers in regard to the silk mill. I should like to know if there has been any practice in applying individual motors to the looms in the cotton mills or silk mills, anything of that kind.

MR. LOZIER:—If the question is asked of me, I would say that there have been a number of attempts made to drive these looms by individual motors; some of them I believe have been quite successful, using small motors about ¼ horse power, and I understand that there are several large installations in contemplation now which will be operated in that way; but I have no definite information on the subject. The problem seems to be to get a motor that runs sufficiently steady and also to keep the first cost down in comparison with the cost of the loom.

MR. H. B. COHO:—I would say in connection with the last speaker's remarks regarding silk mill installations, that I have had a little experience with this style of work and am not quite satisfied with the results. The difficulty which we have had seems to have been to get a motor that would start quickly enough to give the proper results on the looms. We are still making tests on this, however, and hope to accomplish it without the use of clutches or anything of that nature.

MR. DUNN:—About four years ago I equipped some silk

looms with direct-connected motors and the performance was very satisfactory. On account of the steadiness of the working of the motors we were able to increase the picks per minute or the number of times the comb throws back the thread thrown by the shuttle, about 10 per cent, and the freedom from spoiling of silk by waves that will appear if the speed is irregular, was very much greater with direct-connected motors than with belt-driving. The motors were not used by the silk mill for which we made these experiments although we equipped several looms and had them in operation for a number of months. The reason they did not use the motors was because they did not feel there was enough precedent for it. They had a French superintendent who was brought over to establish their works and he was not sure enough of American apparatus to trust it, and then the cost was quite a little above the cost for shafting. On these grounds they ruled the motors out. But the performance of the looms was very satisfactory and much more perfect than with belting. There was not any difficulty of the kind Mr. Coho mentioned in starting quickly enough, since the looms were started by a clutch, and the minute the clutch took hold, the loom went and the motor stood by.

If I may be allowed to make a few comments on some of the other points that have been raised: Mr. Hill said that he believed that there was no limit to the economical subdivision of power. Taking that statement as I believe he meant it, I cannot agree with him, certainly as conditions are at present, and I do not think that they ever will be such that motors will be put upon the smallest tools; the reason Mr. Hill himself pointed out. There are inherent difficulties in the design of very small motors. The regulation is necessarily bad and the cost high, and the facility of control, little. One of the inherent reasons, for instance, why little motors are so, is the fact that for a given volume of copper wire that it is necessary to use in the winding of a certain one-sixth horse power motor that I have in mind, only 38 per cent of that volume is copper; the rest is cotton and wind. This is a condition that will always be with us.

As conditions are at present, I agree with Mr. Smith, although I would put the limit a little smaller than he has put it. I believe it is economical and desirable to-day to put motors directly upon tools for all cases where the motor is one horse power and over. I do not believe in doing it smaller than this, and in a great many cases I do not believe in doing it as small. The standard turning lathe is the most difficult problem to handle, and I would not advise putting one horse power motors to-day on turning lathes. Another point Mr. Smith brought up was the question of the greater amount of light that was obtained when the belts were dispensed with. Just as incidental to that I will mention another fact in connection with the Government Printing Office which I have alluded to before. They keep there

a very accurate record of their sick list. It is such an enormous establishment that this pays. Since the introduction of electric power, the sick list has been reduced 40 per cent. I think that speaks volumes.

Another point in regard to Mr. Leonard's remarks. I am a very strong supporter of Mr. Leonard's methods of control in all of their forms. I believe we have something there that is going to be used more than it is used now, and that it is absolutely the best way of controlling certain kinds of machinery. But I wish I could say that I felt that the method was applicable to a very large class of work that we have to deal with, namely, work involving cutting tools in a machine shop. I do not consider it the best way of controlling such work for this reason: [Making a sketch on the blackboard]. This may represent any kind of machine work. It may represent a large wheel hung horizontally upon a boring mill, or it may represent a large cylinder being turned in a lathe. It has been established that the limit of cutting speed at which we can use this tool is the limit at which the tool will stand up, will not be dulled and will not have its temper drawn by the heat generated. Let us assume that we are surfacing a large circular plate and that we need a cutting speed of 30 feet per minute; now no matter on what diameter we use the tool we want to get a speed of 30 feet, otherwise we are not working our tool up to its full capacity. There will be fewer revolutions per minute the greater the diameter, but the horse power at our cutting tool—the product of the resistance of the tool by the distance over which it cuts—will be constant. Now the consequences are these: When we have large diameters and the speed has to be slow, the torque required to drive goes up. In Mr. Leonard's method of changing the voltage at the brushes of the working motor, which principle applies to all of his methods, this is not accomplished Mr. Leonard's method does not permit the torque of the motor to be increased, although it does accomplish the necessary reduction of speed. Every motor has a certain current capacity. If it is a five horse power motor on 110 volts, 40 amperes is its current capacity, and at that load it is giving the maximum torque for which it is designed and which it will run well under. Now when we reduce the speed of the motor down to say a quarter of its natural speed, in order to make this big piece of work revolve very slowly in order not to make the cutting speed too high, we cannot increase the current and consequently the torque of the armature in proportion as we reduce the speed. This problem is one that I have worked over a great deal and the only satisfactory solution that I can see is: Let us use Mr. Leonard's methods of regulation for certain ranges of speed to get that even gradation that I have mentioned, but for the large ranges of speed use a nest of gears, the principle of which may be illustrated by this: Here we have a pinion, there a gear.

There we have another pinion and here a gear out of mesh with it. Now the motor is connected to one of these shafts and the work to the other. If we wish a high speed and a small torque we leave this connection on. If we wish a large torque and a low speed we throw this gear into mesh with this one and the other out. In that way the motor always runs at its constant speed and therefore is capable of giving the constant horse power which the tool consumes but the revolutions per minute and torque at the work is varied. We have the tool consuming a constant horse power no matter what the speed of the work, and the motor giving a constant horse power. and this seems to me to be the only proper solution for this question. You may obtain these speeds of course in some other mechanical way; but my point is that I believe they must be obtained mechanically, and not by electrically regulating the motor.

MR. LEONARD:—The point that Mr. Dunn makes is one that I have understood perfectly clearly since the beginning of my work in this direction, and it was about nine years ago that the matter was thoroughly threshed out in connection with the operation of a large lathe requiring about 10 horse power in the shop of William Sellers & Co., and I agree with Mr. Dunn in the statement that for the problem as he states it there, mechanical reductions and transformations of a constant power are the only solution, and that you cannot make use of electrical transformations except at greater first cost so long as copper wire gets hotter when the current increases, which is likely to continue. Of course if the motor be made so large as to have a sufficient torque to correspond with the largest torque and slowest speed of your lathe, the same motor will operate perfectly through the entire range. But when you buy the cheapest motor you can buy for that lathe, at its highest speed, it won't be big enough to carry the torque that is necessary for the slowest speed. Personally I have found, and various licensees of mine have found, that a combination of the two makes a very good arrangement; that is: to get wide ranges by means of a few mechanical gears and intermediate gradation that may be required for a great many classes of work by means of the electric regulation.

MR. LOZIER:—I should like to ask Mr. Dunn if it is possible to turn down a large cylinder or to face off a large casting by the method shown: at least, how does he expect to change his gears while the tool is in operation.

MR. DUNN:—Mr. Lozier has me there. I do not limit myself just to gears; but I said mechanical reduction. You might use, if you would, the Evans Reduction Cone which you are undoubtedly familiar with. I have never had much experience with this cone [making a sketch on the blackboard.] But where I have used it it has not been altogether satisfactory. That is a piece of leather belt. These are friction cones, and this is the driving shaft. If the belt is going over there you get

a high speed. If you get the belt so that its running point is here you get a low speed and great torque. You accomplish the same effect that you do with the gears, with no jerks, no intermediate points.

MR. OBERLIN SMITH:—Such an arrangement of gearing can be worked by letting the gears stay in mesh and run loose on the shaft with a series of jaw clutches or friction clutches, contrived to put in action any desired pair; but of course all that makes a good deal of complication. A good mechanical device of this sort has still got to be "threshed out" from somebody's brain fibre.

A question was asked about motors for textile work. I have not had experience with looms, but it may be a matter of interest that some years ago certain clients of mine got me to look into the matter of running every individual spindle of a spinning frame, where there were several hundred, set in a row, running at a speed of 10,000 revolutions a minute, and taking a very small fraction of a horse power each. The parties were among the largest and the richest men in that industry in this country. They were well-known as men who made enormous quantities of spindles and they thought there might be something in the scheme. I then went far enough (with some model spindles that they sent me and some little extemporized motors which were not very efficient) to make up my mind that there was not "anything in it." Such an arrangement is the very extreme ideal application of individual motor driving, I should think. I do not know of any condition in the world, in practical machinery, where we could well divide up a current into more small pieces. If it is ever done it will certainly show that individual motors can be put almost anywhere. I am not perfectly sure myself but what it will be done yet. You all know that in a spinning frame a big tin-plate cylinder or drum runs the whole length and acts as a driving pulley. Each spindle has on it a small grooved pulley called a "whirl" about an inch in diameter. Each belt is nothing but a piece of cotton string tied in a knot. Those knots seem to be a very crude device. It is not practicable to splice the strings, and as some get looser than others they do not give perfectly uniform results in the matter of speed. Not only is there difficulty in keeping this long row of little cotton belts tight alike, but they cannot be adjusted to a general proper tightness to get the best effect without wasting a good deal of power.

This is therefore a case where it is very desirable that we should do away with the drums and all their journals and the air resistance and journal friction, etc.,—as also all those miserable cotton belts, which waste a great deal of power themselves. It doubtless would be very desirable to run these spindles with individual motors, but that is a problem for the electricians to work on. It looks impracticable now, but there may be such

radical improvements made, some day, in motors that we may come to an application of this sort.

MR. DOUGLASS BURNETT:—The remarks of the last speaker remind me that a limitation to the use of direct-connected motors is in respect to high speed. On several occasions the proposition has been presented to me;—Can a direct-connected motor be adapted to centrifugal cream separating or clothes drying machines? As these run at speeds of ten thousand or so turns a minute, I think there would be some difficulty in designing direct-connected motors for them. I should like, also, to refer to the remarks of several speakers, and by combining them, point out that the use of direct-connected motors is limited by the commercial difficulty of having to convince several people as to their advantages and economy. We electrical people believe in them, but then there is, first, the power user who must have a reliable motor and a reliable source of power. The remarks of Mr. Coho indicate that as it is not advisable, for security's sake to run a whole line of shafting and a number of machines from one motor, therefore it is not advisable to use an insecure source of power such as a single dynamo or a single supply service when the current is purchased. The man who can furnish an isolated plant that gives reliable power, or the central station man who can give uninterrupted service through twenty-four hours a day, is going to satisfy, in at least one way, the man who is to buy the motors. I find that electric motors are largely used for coffee roasting for the reason that a reliable source of power is available, as any interruption of the current would very seriously jeopardize the value of a large amount of material. Then too we must get the power user to know, or be able to estimate closely, the amount of power really required and used. They frequently say,—I have five horse power running ten hours a day,—and you will estimate on that basis as to what the cost of the power would be; then when you take other instances where the same size of motor is in similar use,—you find that the cost of power is perhaps one-third or one-half of your previous estimate. In other words, people have excessive ideas as to the amount of power they require, and we should have some way of reducing those ideas; for instance, by seeing that the makers of machines and tools, the makers of planers, drills, printing presses, etc., know the power required by the machines they sell. I have known very few machine builders, in my own experience, to give to users and buyers of their tools any estimate of the amount of power required. I do know that makers of apparatus for coffee roasting and handling do give estimates, and they are the only people who do that. It seems to me that one good way to secure a larger use of electric motors generally, and particularly direct-connected motors, would be to convince not only the owner directly but also the makers of the tools, as to the economy and other great advantages of their use.

Another man to convince is the laborer—the man at the machine. That they appreciate the motors is, I think, very clearly shown by Mr. Dunn's statement that the sick list at the Government Printing Office was reduced by forty per cent. It is also clearly shown by Mr. Hill's remarks on the unsatisfactory results secured by certain motors at the American Book Company. Now I think you will at once grant that if the man who uses the machine— the laborer—can be convinced that the direct-connected motor is the best thing for him to use, we have an important helper.

To summarize—as I said at the beginning, we electrical people are in favor of all electric motors; but we must convince three people of their advantages—the owner of the works, the laborer, and the maker of tools. I think that we need bear this in mind in all our dealings in connection with the subject.

Mr. Oberlin Smith:—I should like to hear from some of my electrical friends who understand designing motors as to what the limitations of speed are; why a motor cannot be made to run 10,000, just as well as any other speed—if we keep within the limits of damage by centrifugal force.

In regard to possible spindle motors; of course they must be without commutators—probably induction motors with two or three-phase alternating currents. I do not myself know any absolute bar to motors excepting their high cost and possibly the weight, too great weight of the armatures. If that could be reduced so as not to be objectionable it seems to me the only real reason against them, is the cost, which probably might always be prohibitory—but who knows?

Mr. Arthur Williams:—Referring to the use of direct-connected motors on small machines, I might mention that a short time ago we heard of the experimental application of three-phase motors to the spindles of a mill in Scotland with satisfactory results. Very high speeds are obtainable and that system permits the necessary instantaneous stoppage and reversal of the machines. We saw, also, while in Berlin last summer, a buzz-saw having a speed of about 4,000 revolutions a minute, driven by an armature directly attached to a short extension of the shaft on which the saw revolved. A planer received its power in the same manner, and all of the wood-working machines of the shop were operated by motors directly attached to their parts. The enormous works of the Allgemeine company of Berlin are equipped entirely with direct-connected machines and tools. The flexibility of this system permits the most convenient and efficient arrangement of the machines; every part of the floor, there being neither shafts nor belts to obstruct the vision, is directly within range of the superintendent's office, and the conditions otherwise are most conductive to health, cleanliness and the comfort of the employees. The power supply is one of the smallest items of shop expense,

while labor is one of the largest, and anything that increases the efficiency, or reduces the cost of labor, is worthy the most careful consideration.

The New York Edison company, feeling that this subject should be brought before the public, its users of power, is arranging to issue a second circular, written by Mr. Powers, who is considered one of the best advertising writers in the country. Illustrating what I mean between the difference in a saving in the cost of power, the small expense, and of labor, the large expense, I might mention an incident that occurred in the experience of Mr. Powers, of which he told me. He was writing for one of the oil companies, the manager of which to that time had simply emphasized the saving in the annual oil bills resulting from use of his oil. Mr. Powers recognized that this was a pretty small item and felt that alone it did not justify the same attention from the busy man at the top that the oil man perhaps thought it should have; he wondered whether the oil, being of higher efficiency, did not also save largely on fuel, depreciation, repairs, etc., and he found it did. In one instance, on one of the large railroad systems of England, where first tried experimentally, the saving in fuel, as one of the items, was so considerable that the allowed engine supply of coal could not be consumed, and I think this item alone came to more than the entire cost of oil.

We had a customer here who in order to meet a sudden demand for his goods was compelled to consider the rental of three additional lofts giving each a complete equipment of sewing machines—previously a single floor, with foot power, being sufficient. He was advised to try an electric motor, being assured that with steadiness of operation and higher speed the output would be largely increased, and this was true to such an extent that the addition of the motor gave the plant sufficient capacity for all requirements and no further changes required. The electric power cost about $40 a month,—less than a single operator received.

But to get back to the point I really want to emphasize: There are several large firms or corporations in Europe devoting themselves entirely to the manufacture of combined machine tools and motors, with the result that this complete apparatus is quickly available. Since our return we have been impressed by what seems a lack of co-operation between the motor and the tool manufacturers, making it possible to secure such apparatus, if at all, only after considerable delay. This was our own recent experience in purchasing some lathes and pipe cutters with motors directly attached. All desire of course that every branch of our profession shall be brought to the highest state of efficiency, and it seems that here is a great opportunity, but the manufacturers must get together. If they do not, the tool makers will be forced to manufacture motors, or the motor manufacturers to make tools.

As to the saving to the user, there seems no possible room for doubt. We are recommending generally the adoption of direct connected motors, but have not as yet quite decided as to how far down we should go in regard to size. It would seem economical to put a motor, directly attached, on any machine requiring more than one-half H. P., and on printing presses and paper cutters and any other machinery using intermittent service. The desirability of attaching motors to sewing machines and the like is probably questionable, as the labor necessary for their maintenance must increase, and this might become a very important item of expense. For a number of sewing or other small machines some subdivision is undoubtedly desirable and economical, as every factory has its dull seasons and the discontinuance of sections at such times would undoubtedly result in considerable saving.

Perhaps the advantages of the direct application of power are nowhere shown so much as in electric elevators. About 14,000 H. P. are now supplied in New York at an annual cost of approximately $18 per H. P. installed; the car mile costs vary from 14c. to 18c., in comparison with from 36c. in winter to 50c. or 60c. in summer as fair average costs of the hydraulic system I speak only of the system which employs an electric motor directly driving the winding drum or screw, and not the electric pumping system, which continues in the hydraulic link all of the disadvantages of that system, other than the continuous supply of the central station, without any saving in the costs.

Permit me, Mr. President, to again emphasize the need which seems to exist in New York of that greater co-operation between manufacturers of motors and of machine tools.

MR. GEORGE HILL:—I think it is generally the fact that in any given plant the engine which will be placed in connection with the dynamo will be a higher grade engine, more economical in its water consumption and better able to do the work and give a longer life than the engine which is ordinarily placed in connection with the shafting or belting. So far as my experience goes there is no comparison at all between the cost of maintenance of an electrically operated plant and a belt-driven plant, the belt-driven plant costing so very much more.

In regard to the illustration which I gave of the American Book Company in regard to the Smyth sewing machine, there was both satisfaction and dissatisfaction. In regard to the presses we found some of the operators intent on wrecking the machine. One of them I had to argue with forcibly to stop it. In regard to certain of the other machines, and some of the more intricate machines, we found the operators not only understood, but were very much in love with them. One of their most expensive machines stayed idle for three months until the man that was intended to operate it was discharged and a new man put in. Every time the old man undertook to run the machine

he tried to wreck it and there was no arguing with him, no way of persuading him to operate that machine properly. After he was discharged there was no trouble. That comes back to the personal equation which exists in every plant.

Very few engineers realize the enormous percentage of loss in the transmission of relatively small powers by belting, due to excessive friction in bearings caused by having the belts too tight. As an illustration I had recently in one of our power buildings, where each one of the tenants is metered, one who had a five horse power motor belted up to a single shaft which ran down through the center of the floor operating his various machines, and his current bill showed that he was using 40 horse power hours a day right along. His machines evidently did not require anything like so much power, so he disputed the bill. I put an ammeter on the motor circuit and measured the power consumption throughout the various transformations, and found that the work was the smallest item—I think about three-quarters of a horse power; all the rest was due to stupid connecting up. His belts were so tight that by slacking the motor back on the stand a little and decreasing the belt tension we took off one horse power. Those are things which are personal, which are not inherent in the machine at all, and unless looked for and guarded against will interfere with good results. It may be said that they are inherent in any belting work since in all such work nobody knows the amount of power that is being consumed, nor can anyone make any proper estimate of it from looking over the shop, and it is only when we use a motor and an ammeter in the motor circuit that we actually know what we are doing.

Mr. Jesse M. Smith:—It seems to me that the key note of this whole question of electric transmission is that the electric motor is more convenient, more flexible and more directly applicable than any other form of power transmission. The question of economy in friction between the cylinder of the slow speed Corliss engine and the tools that are driven at the other end, whether by shafting or by electrical transmission, is a mere trifle in favor of electricity; it may amount to 3, 4, 10 per cent., but rarely more than 10 per cent. From the point of view of saving in friction, there is nothing in it; that is when all the tools are in operation. In scarcely any factory, (not even a textile factory, and certainly not in any machine shop,) are one-third of the tools in operation at any one time. It may seem extraordinary to make the statement that in a textile factory for instance there is a loss of time at the machines, but such a loss exists, and the economy of electric transmission is due to the motors being stopped when the machines stop. Where line shafting is used it has to be running all the time; it has to be made strong enough to supply the maximum demand but generally supplies much less. I had occasion only recently to go over the question of transmission in a very large manufacturing establishment

where the buildings were scattered over a large territory, and where the machines were driven by line shafting and belting. The question was whether it was desirable to throw out the shafting and belts and go to electric transmission. I figured it over quite carefully and found a saving of just about 10 per cent. in the amount of friction. The parties told me that nearly all the tools ran constantly, that the line shafts must always be running and that the tools themselves, while not all being constantly in use, must be always ready for use. The question of electric transmission in this case, so far as the saving in friction was concerned, was practically not worth the expense of the change. The whole question comes back, as I said before, to the convenience and elasticity of electric transmission, and my idea is that an individual electric motor should be placed on every machine. The limit to which it can be carried downward, is simply a question of dollars and cents—how cheap a motor can you get to do the work? As the gentleman who last spoke said, there is a difference between the machine builder and the motor builder;—they must get together, and if they do not get together there will be trouble. The machine builders are already beginning to build motors. My idea is, that very soon every company building machine tools will build its electric motors in its own factory, and will build them as simply and as cheaply as it now builds machine tools. When that time comes, we will see the smaller tools supplied with smaller motors, and there is no telling where the limit may be. We may even see Mr. Oberlin Smith's idea realized,—each individual spindle moved by an electric motor. Mr. Smith touched upon a very important point which I should like to see brought out more fully. We have not heard to-night whether the current for these motors is direct or alternating. Alternating seems to be the craze just now, and if there is anybody that knows anything about alternating motors—I do not—I would like to hear something about them.

Mr. Oberlin Smith:—My experience with driving presses, etc., has usually been with a direct current—110 volts and 220 volts, so far. I think one reason for the prejudice, if there be such, against alternating currents is on the same order as the feeling that one must not "monkey with a buzz saw;" people do not want to handle the high potential alternating currents usually found on the market.

Mr. Williams:—Mr. President, would you allow an additional word as to losses? As I left the office this afternoon, one of our engineers handed me a statement as to losses on shafting running on the local system. The percentages vary as follows: 43%, 23%, 21%, 43%, 68%, 61%, 27%, 29%, 35%, 22%, 66%, 41%, 52%, 37%, 29%, 18%. We have found shaft loss variations from 5% to 70%, and in some instances still higher.

The President:—How are those measured, Mr. Williams? Is that with a full load on—all the tools working?

MR. WILLIAMS:—At maximum and average load; these figures show the shaft losses on average loads.

MR. GEORGE HILL:—While we are on that point I wish to state that I have taken a great many indicator cards from engines under ordinary working conditions, taking not a single card but continuous cards, running over a period of from a couple of hours to three or four days, and then afterwards I have indicated the engines when the shaft and transmitting belting alone was on and the work all thrown off, and I have never found a case in which the friction losses were less than 50 per cent. of the average load, and I should not believe, unless it was backed up by voluminous figures, that there are any cases of any size in which the shaft losses were as low as 10 per cent. of the average load. I should want to see the most careful and complete figures and know all of the facts bearing on them. I have a great many observations given to me by my friends of similar plants, and I find in no case does the loss drop below 30 per cent. except here and there, in isolated cases, where there are special conditions, and in ordinary practice such as we meet here in New York in buildings, the losses are certainly very much greater than 30 per cent. In regard to a high speed motor I would like to state that I have seen a generator which was designed to run at 5,000 revolutions per minute, and almost the heaviest parts of that generator were the two rings which were used to keep the commutator bars on. The commutator was about four inches in diameter and these rings, as I recall them, were about four inches internal diameter and five and one-half inches external diameter and about three-quarters of an inch thick.

MR. HAMBLET:—Mr. President, I have been much interested in this discussion, and I have an idea that many of the gentlemen present feel as I do, and that is that they would like to hear an expression from yourself, sir, in regard to the discussion.

THE PRESIDENT:—The subject under dicussion is of great importance not only to ourselves as a body, but to the manufacturing community at large. The position of the United States among the nations of the world as a manufacturing country depends upon the mechanical facilities possessed for manufacturing on a large scale, and upon the average intelligence of the workman to avail himself of those facilities. For this reason, all that facilitates and accelerates the operations of tools is directly advantageous to manufacturing and commercial ascendency. Just as in other departments of electrical applications, it is not merely the saving in first cost which is effected by electrical methods of distribution, but the pliability and convenience of electric methods which has won for them success. It is the ease of control of an electric motor, its handiness, convenience and the flexibility of the wire or wires which supply it, that makes the electric subdivision of power so valuable an adjunct

in manufactories, and it may well happen, as has been pointed out this evening, that where there is no seeming advantage in economy by the subdivision of electric motive power, a great advantage may accrue in convenience and facility of operation, and the increased output thereby promoted.

[Adjourned.]

DIED.

SHEBLE:—At Philadelphia, April 20th, 1899, Franklin Sheble, late of the firm of Sheble and Patton, of Philadelphia, and representative of the Stanley Electric Company, at 71 Broadway, New York. Mr. Sheble was born in Philadelphia, April 10th, 1866, and was educated at the Philadelphia Central High School, the University of Pennsylvania and Cornell University. After about six years experience with the General Electric Company, at Lynn and Schenectady, he formed a partnership with Mr. Price I. Patton, as electrical engineer and contractor, and was more recently identified with the Stanley Electric Co., at the New York office. Mr. Sheble was elected an associate member of the INSTITUTE October 21st, 1890, and transferred to membership December 18th, 1895.

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